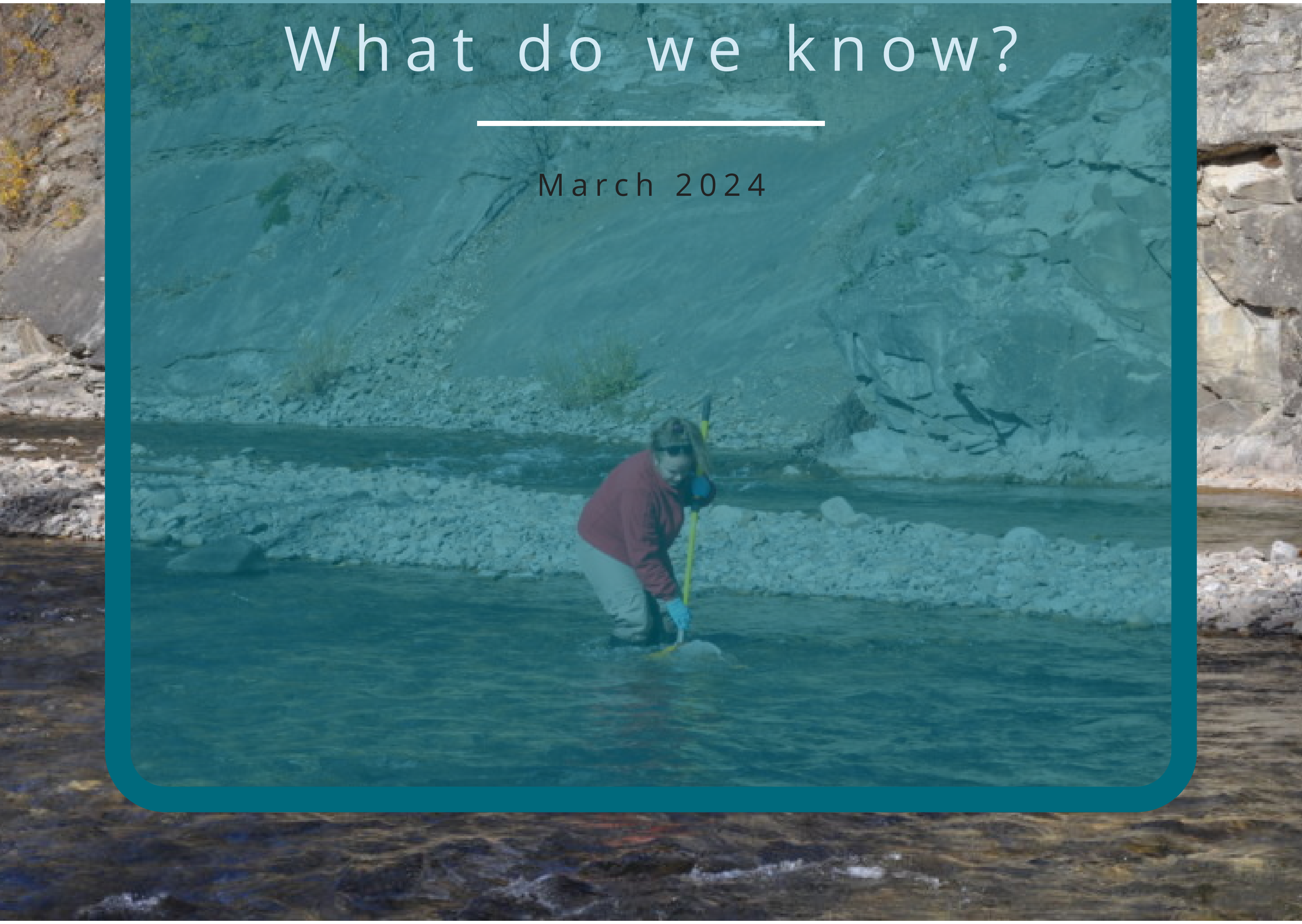
Athabasca WATERSHED COUNCIL

Alberta Conservation Association

Benthic Invertebrates in the Athabasca Watershed: What do we know?

March 2024



Cover photo: CABIN Sampling in the McLeod River

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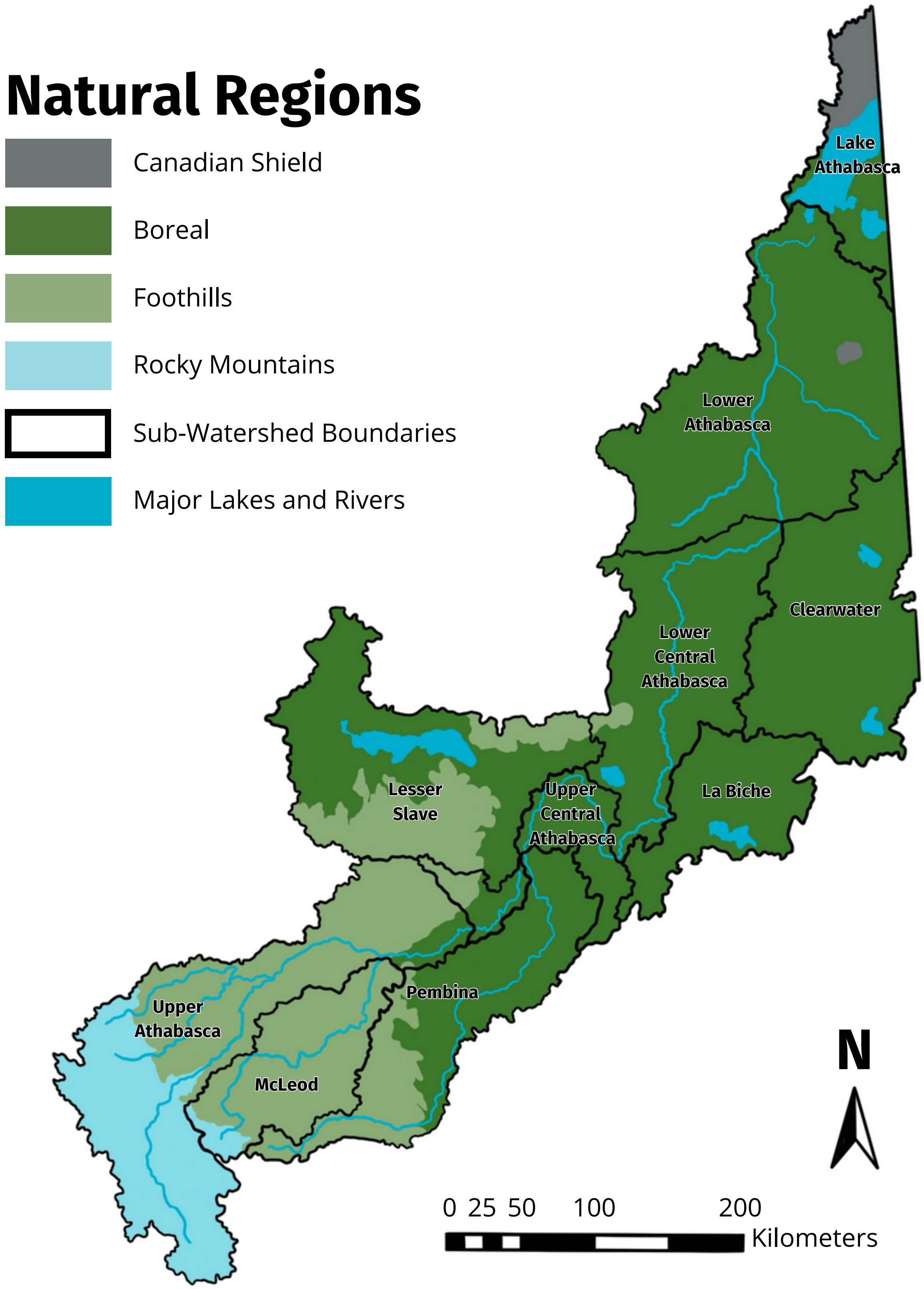

Figure 1. Map of the Athabasca watershed with sub-watershed boundaries.

Executive Summary

Benthic invertebrates are small spineless aquatic animals and larval stages of insects that live in or on the bottom of streams, wetlands, and lakes. Benthic invertebrates are strongly influenced by their environment, including water quality, sediment, and habitat, making them a good indicator of watershed health. Given the importance of benthic invertebrates, the Athabasca Watershed Council conducted a literature review on what is known about benthic invertebrates in the Athabasca watershed. The objective of this report is to help inform future benthic invertebrate work in the Athabasca watershed and summarize existing information on benthic invertebrates in the Athabasca watershed.

To date, there are still sub-watersheds in the Athabasca watershed that have few benthic invertebrate datasets including the Pembina River sub-watershed, La Biche sub-watershed, and Lake Athabasca sub-watershed. The Lower Athabasca sub-watershed has plenty of data on benthic invertebrates due to the Athabasca Oil Sands activity. The Canadian Aquatic Biomonitoring Network database and World Wildlife Fund Watershed Reports have datasets about benthic invertebrates on the entire Athabasca watershed.

Twenty-two resources were referenced in this literature review. In this report, an introduction is summarized prior to discussing this literature review's method. The results section discusses benthic invertebrate data in each sub-watershed before looking at the benthic invertebrate data for the entire Athabasca watershed. Then, the discussion section reviews the data gaps and leads to the conclusion. References are available at the end of this report.

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Introduction

The Athabasca River, a vital natural resource, originates in the Columbia Icefield within Jasper National Park, flowing 1,231 kilometers before flowing into Lake Athabasca. Extending approximately 159,000 square kilometers, its watershed is divided into ten sub-basins: Upper Athabasca, McLeod River, Pembina River, Upper Central Athabasca, Lesser Slave, La Biche, Lower Central Athabasca, Clearwater River, Lower Athabasca, and the Lake Athabasca sub-watersheds. These regions support industries such as forestry, recreation, oil and gas, tourism, and agriculture.

The Athabasca Watershed Council (AWC) aims to manage the Athabasca River watershed by addressing ecological, social, and economic concerns through monitoring, research, and collaborative engagement with government bodies, industries, stakeholders and Indigenous groups.

To evaluate the effects of anthropogenic activities, pollution, and other environmental stressors on ecosystems, biomonitoring is employed by the AWC. Biomonitoring is the practice of using living organisms as indicators to assess the health and quality of the aquatic environment.

Benthic invertebrates are small organisms without backbones that inhabit the sediment at the bottom of water bodies. These organisms can include species of insects, crustaceans, mollusks, and worms. They play a vital role in the ecosystem, serving as food sources for fish and contributing to organic matter breakdown, nutrient cycling, and sediment mixing (Reece & Richardson, 1999). These organisms serve as excellent bioindicators due to their sensitivity to environmental changes. Specifically, mayflies, stoneflies, and caddisflies, collectively called EPT taxa based on their scientific order names (Ephemeroptera, Plecoptera, and Trichoptera), stand out as exceptional indicators for aquatic ecosystem health. These insects surpass other benthic invertebrates in their sensitivity to environmental shifts and are considered pollution-intolerant. A higher abundance and species diversity of EPT taxa correlates with healthier water conditions. Conversely, areas where chironomids and damselflies (Odonata) outnumber EPT taxa indicate poor water quality, as these species exhibit greater tolerance to adverse aquatic conditions.

Currently, the collection of benthic invertebrates is effectively executed using the Canadian Aquatic Biomonitoring Network (CABIN) sampling protocol. This approach is currently employed throughout Canada to evaluate the well-being of aquatic ecosystems. This process entails the targeted gathering of benthic macroinvertebrates at specific locations using kick-sampling techniques. The CABIN protocol is used with Sequencing the Rivers for Environmental Assessment and Monitoring (STREAM) eDNA metabarcoding procedure and taxonomic analysis. The Hilsenhoff Biotic Index (HBI) is a frequently applied tool for gauging water quality concerning benthic invertebrate communities. The HBI evaluates the abundance and diversity of benthic macroinvertebrates to determine the water quality of freshwater ecosystems. The calculation of the HBI score considers how sensitive various species are to pollution. According to this framework, higher HBI scores represent ecosystems with poorer water quality because they are dominated by species that can withstand pollution, whereas lower scores represent healthier ecosystems because more pollution-sensitive species are present.

This literature review aims to increase and synthesize our knowledge of benthic invertebrates in the Athabasca River watershed. It will involve locating sub-basins where data on benthic invertebrates are available, evaluating data gaps within the watershed, and reviewing the methods for gathering data.

Methods

The methodology for this literature review employed a systematic approach. Initial resource gathering involved systematic keyword searches across diverse sources such as Google Scholar, the CABIN database, WWF Watershed Report data, and Regional Aquatic Monitoring Program data. The core of the review was built on the examination of 22 resources. This paper's Results section contains a detailed analysis and discussion of the literature search results. The Discussion examines the insights, patterns, and gaps found among the reviewed studies and results in recommendations based on the collected literature for future research.

Results

Upper Athabasca Sub-watershed

The Upper Athabasca sub-basin covers a total area of 25,195 square kilometres, and the land is used for forestry, gas extraction, recreation and tourism (see Figure 1). It is located in the province's western region and encompasses an extensive portion of the Canadian Rockies and the foothills area. Both Jasper National Park and Banff National Park are part of the watershed.

As part of the Northern River Basins Study, research conducted by R.L. & L. Environmental Services Ltd. (1993) involved the collection of aquatic macroinvertebrate samples from six locations in the upper Athabasca River, spanning the Hinton through Whitecourt area during April 1992. Stomach content samples were also gathered from mountain whitefish and northern pike in the spring of the same year. These sample sites encompassed areas near specific landmarks, upstream of Hinton near Entrance, Weldwood Bridge, Obed Mountain Coal Bridge, Emerson Lakes Bridge, Berland Bridge/Knight Bridge, and Windfall Bridge. The processing of benthic invertebrate and fish stomach samples acquired during these projects was the responsibility of R.L. & L. Environmental Services Ltd. This study forms part of a pilot program investigating the movement of trace contaminants through the food chain, also known as bioaccumulation.

The Culp et al. (2000) study of autumn 1993, in collaboration with the Northern River Basins Study (NRBS), focused on the effects of bleached kraft mill effluents (BKME) on riverine food webs in the upper Athabasca River near Hinton. The researchers conducted mesocosm experiments and field observations to determine the impacts of BKME on periphyton biomass, benthic insect density and composition, and the biomass of abundant invertebrates. The experiments showed that BKME concentrations equivalent to levels in the Athabasca River did not cause measurable toxicity. However, they did lead to enrichment effects, including periphyton and insect biomass increases and invertebrate abundance. The study concluded that the response to BKME in the Athabasca Basin is primarily one of nutrient enrichment rather than toxicity. Benthic invertebrates were collected by enclosing stones in the river with a U-net, lifting them from the streambed, and placing them into containers of river water. This ensured that the associated periphyton and invertebrates remained with the stone, and any invertebrates under and around the base of the stone were also collected.

According to the World Wildlife Fund (2020), the health assessment of benthic macroinvertebrates within the Upper Athabasca sub-watershed had a "Very Good" status based on available data from 2015 to 2019. The cumulative Hilsenhoff Biotic Index (HBI) value for benthic invertebrates, derived from the five-year dataset, stood at 3.81 (Very Good; possible slight organic pollution). The data originated from CABIN, with 79 sampling sites. The amount of data collected was partially sufficient.

A collaborative study with STREAM and the Athabasca Watershed Council was conducted on the Upper Athabasca and McLeod sub-basins in October 2021. Sampling was performed in Solomon Creek within the Upper Athabasca watershed. This site had an HBI value of 3.9, indicating a rating of "Very Good." Solomon Creek had higher amounts of chironomids than EPT taxa, indicating poorer water quality than the other sites in this study. The study utilized the CABIN protocol for collecting benthic macroinvertebrate DNA samples, which were then sent to the University of Guelph Centre for STREAM metabarcoding analysis.

Parks Canada collects benthic invertebrates at 30 sites in the Upper Athabasca watershed using the CABIN protocol. The data can be found in the State of the Park reports for Jasper National Park that are produced every 5-years. In 2018, it was found that water quality was ‘good’ based on the benthic invertebrates collected and the reference condition at pristine rivers in the park.

McLeod River Sub-watershed

The McLeod sub-basin covers a total area of 9,658 square kilometres, and the land is used for forestry, agriculture, coal, aggregate mining, and energy extraction (see Figure 1). It is located in the province's western region, just south of the Upper Athabasca watershed and supports most of Yellowhead County.

During the review of the Coal Valley Mine Robb Trend Project Environmental Impact Assessment (2012), a significant finding emerged from the baseline benthic invertebrate surveys conducted on nine watercourses within the Project area. The results revealed that the benthic invertebrate communities at almost all flowing sample sites were predominantly composed of Ephemeroptera, Plecoptera, and Trichoptera taxa. These three groups played a dominant role in the aquatic ecosystem. Additionally, the Chironomidae and Coleoptera taxa were observed to be the only other two groups that commonly accounted for more than five percent of the remaining taxa.

As mentioned previously, in the 2021 collaborative study with AWC and STREAM, they further sampled three more sites in Gregg River, Whitehorse

Creek, and McLeod River, all within the McLeod River sub-basin. All three sites indicated "Excellent" water quality via their HBI values of 3.3 for Gregg River, 2.8 for Whitehorse Creek, and 2.4 for McLeod River. All sites had significant amounts of EPT taxa present, indicating less pollution. The study utilized the CABIN protocol for collecting benthic macroinvertebrate DNA samples, which were then sent to the University of Guelph Centre for STREAM metabarcoding analysis and CABIN taxonomists for species and genus identification. This project has been active since 2021, showing similar results from the first year of data collection at the same sites for 2022 and 2023. In 2022, the AWC added more sites on the McLeod River, Embarrass River, and Gregg River.

Pembina River Sub-watershed

The Pembina watershed covers an extensive land area of 14,324 square kilometres in Alberta, where it accommodates various land uses, including forestry, agriculture, and energy extraction (see Figure 1). It is located in the province's western region, southeast of the Upper Athabasca and McLeod watersheds. This watershed supports communities in part of Yellowhead County and the counties of Barrhead and Westlock.
There is a significant data gap concerning benthic invertebrates in the Pembina River sub-basin, primarily due to the need for more sampling and research conducted in this region.

Upper Central Athabasca Sub-watershed

The Upper Central Athabasca watershed covers a total area of 6,138 square kilometres (see Figure 1). The land is used for agriculture, forestry, energy extraction, and mining. This watershed is located just north of the Pembina watershed. The watershed supports parts of Athabasca County, Fort Assiniboine and the M.D. of Lesser Slave River.

In a study by Mueller (2015) and the Upper Athabasca Community based Monitoring Project, an assessment of heavy metal toxicity in the sediment and water of the Athabasca River was conducted at 12 sites between Hinton and Athabasca between 2014 and 2015. To do so, CABIN protocols were utilized. The potential for more negative consequences from development in the Klondike Ferry region was found to be high due to its heightened levels of copper, lead, and zinc. The copper, lead, and zinc concentrations were around 41%, 30%, and 46% of their harmful thresholds, respectively. Even minor increases in the buildup of heavy metals could modify the local invertebrate population and potentially trigger bioaccumulation as prey for fish.

As per the World Wildlife Fund's (2020) Peace-Athabasca Watershed report, the assessment revealed data insufficiency for benthic invertebrate sampling and monitoring in the Upper Central Athabasca region during 2015-2018. The dataset gathered from 35 CABIN protocol sites exhibited an average HBI value of 4.8 (Good; some organic pollution probable) across this five-year duration.

Lower Central Athabasca Sub-watershed

The Lower Central Athabasca watershed covers 16,412 square kilometres and is primarily used for forestry and in-situ energy extraction (see Figure 1). This watershed is located in the southern Municipal District of Opportunity No. 17. It includes the community of Calling Lake.

According to the World Wildlife Fund (2020), the Lower Central Athabasca sub-basin is given a benthic health rating of "Fair." This rating is according to partially sufficient data from 2015-2018, with 58 CABIN protocol sites and 17 Regional Aquatic Monitoring Program (RAMP) sites. In these five years, the benthic invertebrates sampled displayed an average HBI of 5.38 (Fairly poor; substantial pollution likely).

La Biche Sub-watershed

The La Biche watershed covers a land area of 8,671 square kilometres and is used mainly for agriculture, oil and gas extraction, recreation and tourism (see Figure 1). This watershed supports parts of Athabasca County and Lac La Biche County.

Using bottom sampling, Pinsent (1967) conducted a study on the plankton and benthic fauna communities of Lac La Biche. The investigation revealed diverse benthic invertebrates, including annelids, arthropods, mollusks, and EPT taxa. Dipterans (Chironomidae), pelecypods, and amphipods were the dominant groups by abundance and biomass. The quantitative assessment of the macroinvertebrate population in Lac La Biche over two years yielded a measurement of 79.61 kg per hectare.

A notable deficiency in recent research and sampling of benthic invertebrates is evident within the La Biche watershed.

Clearwater River Sub-watershed

The Clearwater River watershed covers 16,893 square kilometres and is used for forestry and oil extraction (see Figure 1). This watershed is in the southern part of the Regional Municipality of Wood Buffalo with the headwaters located in Saskatchewan.

During the fall of 2015, benthic invertebrate communities were examined in the Clearwater River watershed, including a depositional test reach, depositional baseline reach in the Clearwater River, and an erosional baseline reach in the High Hills River, as detailed in a 2015 report by Regional Aquatic Monitoring Program and the Joint Oil Sands Monitoring Plan (JOSM). The study assessed changes in measurement points related to benthic invertebrate communities. These changes were found to be minimal to low in significance at the test site in the Clearwater River. In the specific test reach of the Clearwater River, variations in benthic invertebrate communities didn't show any substantial connection with oil sands development. Moreover, the presence of sensitive EPT taxa indicated that the conditions did not harm the overall benthic communities in that area.

Lower Athabasca Sub-watershed

The Lower Athabasca sub-watershed, spanning 27,077 square kilometres, is vital in supporting forestry and energy extraction, and is a significant space for Indigenous communities' traditional practices and cultural heritage within the Regional Municipality of Wood Buffalo (see Figure 1).

In a study by McCart et al. (1977), baseline investigations were conducted concerning the aquatic ecosystems within the Athabasca River region. These comprehensive examinations were commissioned by Syncrude Canada Limited and centred around the geographical area adjacent to Syncrude's Lease Number 17. This location aligns with the Athabasca River's western shoreline, situated north of Ft. McMurray, Alberta. The study aimed to characterize benthic invertebrate communities upstream and downstream of a potential effluent discharge, quantify riverbottom animal populations, and identify an optimal method for monitoring water quality through benthic macroinvertebrate sampling. Fifteen permanent monitoring stations made up the study area. At each site, two methods were used for invertebrate sampling. First, three artificial substrate samplers, each consisting of an "Easy-Way Bar-B-Q Tumble Basket" filled with crushed quarry rock, were suspended 15 cm above the substrate for 30 days. The collected material was washed and preserved for identification. Second, aquatic invertebrates were sampled using a modified Ekman-type grab, with samples washed and preserved for later analysis.

According to Barton & Wallace (1979), compared to areas upstream, the Steepbank River's section that flows through the Athabasca oil sands deposit has a less diverse benthic invertebrate community. Plecoptera and

Trichoptera diversity and abundance are consistently lower in areas exposed to oil sand. Like bedrock, oil sand is a substrate for benthic invertebrates, supporting about 60% fewer organisms per unit area than nearby rubble substrates. Compared to rubble, organisms that burrow and are negatively phototropic on oil sand are significantly less common. A riffle close to the mouth of the Steepbank River is flooded during high Athabasca River discharge, creating a pool. Due to this flooding, rheophilic forms like Baetis and Simulium are eliminated, which reduces benthic standing stocks by 50%. However, the invertebrate community bounces back quickly when the normal current conditions are returned. The techniques employed for gathering benthic invertebrates in this study included the Surber sampler, the airlift sampler, and the formalin application for preservation purposes.

In a study led by Barton (1980a) from the Department of Biology at the University of Waterloo in Ontario, Canada, the focus was on examining benthic macroinvertebrate communities in the Athabasca River near Ft. Mackay, Alberta, during the 1977 open water season. The study aimed to uncover how variations in sediment characteristics, in tandem with the river's fluctuating discharge, influenced the abundance and composition of invertebrate communities. The researchers gathered benthic invertebrates using diverse collection methods, including airlifts, Ekman grabs, hand-picking, and dipnet collections. The study collected 114 taxa, with 31 occurring frequently in over 65% of the samples. Fauna composition and diversity differed among sampling stations and months, with major taxonomic groups like Plecoptera, Ephemeroptera, and Chironomidae varying across sites and months. Substrate stability and sediment texture impacted invertebrate community diversity and abundance, with higher diversity on bedrock and accumulating fine sediments than eroding substrates. Taxonomic group abundance varied, with certain species more prevalent in tributary streams than in the Athabasca River.

In 1976-77, Barton (1980b) investigated the impact of oil sand mining on aquatic life in northeastern Alberta. Focusing on mayflies and stoneflies, crucial water quality indicators, the study aimed to assess the effects of mining activities. Sampling involved diverse methods, such as mesh nets and winter openings in the ice, with specimens preserved for analysis. Adult insects were collected using traps and nets. Fast seasonal mayflies were found in silt-laden pools, while slow seasonal ones and stoneflies preferred shallow, swift stream sections. The study revealed distinctive seasonal development patterns. The species mix included Cordilleran, Northern, and Eastern types, indicating potential Eastern migration via glacial Lake Agassiz to the Athabasca River drainage.

Walder & Mayhood (1985) of Sigma Biometrics and FWR Freshwater Research Ltd., respectively, conducted a study based on the Athabasca River, specifically between Fort McMurray and the Tar River confluence. The study's aim was analyzing monitoring data for benthic invertebrates and water quality from earlier studies on the Athabasca River. Concerns about the Athabasca oil sands region's industrial development, specifically the buildup of metal and hydrocarbon pollution in the Athabasca River, are discussed in their report. Water quality and benthic invertebrate data have been tracked since 1976 to assess baseline water quality and pinpoint areas impacted by industrial development. The study, which focuses on a 75 km section of the Athabasca River, presents a statistical analysis of the information obtained from earlier studies in 1981. Principal component analysis and correlation analysis determined what relationships existed between benthic invertebrates and water quality parameters. Benthic invertebrate data from the study were collected in 1981, whereas water quality data were collected from 1976 to 1983. A method other than random selection was used to gather benthic invertebrates. Three replicate samples were taken at each station, with a ten-meter gap between each sample. More samples were taken, and the three that were the most similar were chosen if there was a difference in the volume of debris in the jars of more than 50%. The study examined the relationships between water quality, benthic invertebrate abundance, and community composition in the Athabasca River. The analysis aimed to determine the correlations between various water quality parameters and benthic invertebrate data. The study revealed notable distinctions in water quality and benthic invertebrate abundance within the research area, primarily observed between the two sides of the Athabasca River. These disparities mainly stemmed from the influences of the Clearwater River and other tributaries on the east bank. Some variations in benthic invertebrate abundance and community makeup were potentially linked to Fort McMurray sewage effluent nutrient enrichment. Despite this, no substantial evidence indicates significant variations in benthic invertebrate populations between stations just upstream and downstream of the Suncor development, suggesting that the Suncor effluent might not be a prominent factor. Various benthic invertebrate taxa abundance seems to align with specific water quality parameters, particularly those showcasing distinctions between the river's two sides.

In collaboration with the Regional Aquatic Monitoring Program (RAMP), Golder Associates Ltd. (2003) conducted a review of the Oil Sands Region's benthic monitoring program. The report assessed historical benthic invertebrate data up to the 2001 RAMP survey, aiming to improve the RAMP program by leveraging past insights and establishing a baseline for future trend analysis. Previous benthic research utilized credible sources using accepted methods to focus on quantitative community data. Data from rivers and streams were organized into digital spreadsheets with streamlined references after summarizing data characteristics. While standing water data sources were acknowledged, no summaries were provided. Historical data in the Oil Sands Region were quantified using site datasets from significant rivers, combined small streams, and still waters both north and south of Fort McMurray. Summaries for the Athabasca River, major tributaries, and streams covered habitat features, essential benthic variables, and yearly variations, alongside species lists. 63 studies spanning 1970 to 2001 were identified, with about 25% of 50 studies focusing on the Athabasca River. North of Fort McMurray, sampling included 78 sites in the Athabasca River, 52 in major tributaries, 55 in small streams, and 24 in standing waters, often with multiple samples yielding numerous data sets. South of Fort McMurray, 61 river/stream and 21 lake sites were sampled. Common tools included Ekman grabs for sediment areas, Neill cylinders/Surber samplers for erosion-prone sites, and rock-filled baskets for various habitats.

The Joint Oil Sands Monitoring Plan (JOSM) is supported by the Regional Aquatics Monitoring Program (RAMP) and the Alberta Environmental Monitoring, Evaluation, and Reporting Agency (AEMERA). The Final 2015 Program Report covered most of the Lower Athabasca Watershed and contains data on benthic invertebrate communities. The research encompassed four depositional test stations, and its results demonstrated fluctuations in measurement endpoints of benthic invertebrate communities. At Big Point Channel, Fletcher Channel, and Embarras River stations, these variations were categorized as "Negligible-Low" change from baseline (that is, before the 2015 report). In contrast, the Goose Island Channel station displayed "Moderate" variations due to the substantial organism abundance (surpassing 120,000 individuals per square meter) and the predominance of tubificids.

In 2011, the Canadian and Alberta governments initiated the Joint Oil Sands Monitoring Plan (JOSM) to evaluate surface water quality, air quality, and biodiversity in the lower Athabasca River region, covering Fort McMurray to Lake Athabasca. This plan includes studying benthic invertebrates in the Athabasca River, its tributaries, and the Peace-Athabasca Delta wetlands. The Lower Athabasca River (LAR) generally demonstrates healthy conditions, with abundant Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa. However, some mid-river areas show slight environmental stress. Disturbed zones exhibit different assemblages, potentially due to human-induced stress. Culp et al. (2018) used the CABIN protocol to conduct their sampling. Tributaries generally show healthy benthic assemblages dominated by intolerant taxa, but those influenced by human activities diverge from reference sites due to mild stress. The Peace-Athabasca wetlands' benthic assemblages exhibit high biodiversity with no evidence of cumulative effects from oil sands activities (Culp et al. 2018).

Culp et al. (2020) undertook a research initiative as part of the Joint Alberta-Canada Oil Sands Monitoring program, focusing on the Lower Athabasca River. The study spanned three years, from 2012 to 2014, with annual sampling conducted between September 15-30. The investigation's main objective was to evaluate the potential cumulative effects of anthropogenic activities and natural bitumen geology exposure on benthic macroinvertebrate assemblages in the river. The research team employed the kick-sampling method following the established CABIN (Canadian Aquatic Biomonitoring Network) approach. This involved using a 400 μm mesh kick net and performing upstream movements for 3 minutes while disturbing the substrate to collect benthic macroinvertebrates. The samples obtained were preserved in 95% ethanol and underwent standardized sorting and identification procedures. The study aimed to provide insights into the potential impacts of various factors on the river's ecosystem but also sought to establish baseline data for future biomonitoring comparisons and explore associations between environmental variables and changes in benthic macroinvertebrate communities.

As per the World Wildlife Fund (2020) and the Peace-Athabasca watershed report, the Lower Athabasca sub-basin was given a benthic health rating of "Good." This rating was based on sufficient data from 2015-2018. 413 sites were sampled by CABIN protocols and the Regional Aquatic Monitoring Program (RAMP). Over the most recent five-year sampling duration, benthic invertebrates in this sub-basin had an average HBI value of 4.91 (Good; some organic pollution probable).

Lake Athabasca Sub-watershed

The Lake Athabasca watershed spans 6,562 square kilometers and traditional land use for Indigenous communities in Northeastern Alberta is the main land use (see Figure 1). Wood Buffalo National Park is in this watershed, along with the Peace-Athabasca Delta. Portions of this watershed are in northern Saskatchewan and a small amount is in southern Northwest Territories.

Given the need for more sampling efforts in this region, a substantial data gap is apparent in the Alberta portion of the Lake Athabasca sub-watershed.

Athabasca Watershed

Overall, the Athabasca watershed covers an extensive area of approximately 159,000 square kilometres. It spans diverse terrains, including the Rocky Mountains, Foothills, Boreal Forest, and Canadian Shield. The watershed supports various land uses such as tourism, forestry, agriculture, and energy extraction and is of significant cultural and ecological importance to Indigenous communities.

The Northern River Basins Study (NRBS) final report investigated the connections between industrial, agricultural, municipal, and developmental activities in the river basins of Peace, Athabasca, and Slave from 1991 to 1996. Research areas focused on contaminants, drinking water, the food web, hydrology/hydraulics, nutrients, alternative river applications, synthesis and modelling, and traditional knowledge. Regarding benthic invertebrate findings due to nutrient fluctuations, the Athabasca River has experienced varying degrees of elevated plant abundance and increased growth in benthic invertebrates and downstream fish, according to NRBS research. Although these mills discharge pollutants that may impede growth, these pollutants are not present at high enough to prevent the growth of plant life or populations of benthic invertebrates.

The Athabasca Watershed Council conducted a comprehensive assessment of the watershed's state through a four-phase approach. Phase 3 of the Athabasca State of the Watershed Report (2013) examined three invertebrate datasets from 2007 to 2011. These datasets include Environment Canada's Canadian Aquatic Biomonitoring Network (CABIN) dataset, Alberta Environment and Sustainable Resource Development's

(AESRD) Long-Term River Network Healthy Aquatic Ecosystems (LTRN-HAE) dataset, and the Regional Aquatics Monitoring Program (RAMP) dataset. The report observed variations in these communities from upstream to downstream due to natural changes in river characteristics. Benthic invertebrates near Hinton displayed higher abundance and diversity, predominantly composed of mayflies and stoneflies. Caddisflies and mayflies, with lower overall abundance, dominated the community near the Town of Athabasca. Downstream areas were characterized by a low benthic invertebrate abundance, mainly chironomids. Pollution sensitivity indices were employed to assess the communities, revealing very good water quality near Hinton and the Town of Athabasca, transitioning to good upstream of Fort McMurray and fair near the river's end.

Mueller (2015) and the Upper Athabasca Community based Monitoring Project conducted research on the harmful effects of heavy metals in the Athabasca River's sediment and water. This assessment was conducted at twelve locations spanning from Hinton to Athabasca from 2014 to 2015. The methodology employed for this assessment involved the utilization of CABIN protocols.

The Upper Athabasca Community Based Monitoring Report done by McDonald (2016), as a follow-up to Mueller's (2015) report, examined the overall water quality of the Athabasca River between Hinton and the Poacher's Landing Campground in the Lower Central sub-watershed. Trained volunteers sampled benthic invertebrates following CABIN, WetPro, and CCME protocols at 15 sites between Entrance and Athabasca between October 1st and 7th, 2016. The samples underwent analysis at a laboratory accredited under ISO 17025 for various parameters. This report seeks to raise awareness of the Upper Athabasca Basin's water quality issues and to promote the protection of watersheds and water resources for the good of the local population. It provides information on collecting and evaluating water, sediment, and benthic invertebrate specimens obtained from various locations throughout the basin.

Discussion

As one of the most researched sub-watersheds of the Athabasca River, the Lower Athabasca reveals some patterns in the studies discussed. There was an abundance of papers that covered the Oil Sand Region. Diverse sampling techniques were employed over time, ranging from airlift samplers and Ekman grabs to CABIN sampling protocols. The impact of oil sands emerged as a consistent theme, with oil sand areas exhibiting lower diversity and abundance of specific taxa.

Notably, sensitive EPT taxa suggests that pollution impact might be mild in certain regions. Human-induced stressors were identified as causing differences in benthic assemblages, particularly in disturbed zones and certain tributaries. Monitoring programs like the Joint Oil Sands Monitoring Plan (JOSM) and the Regional Aquatic Monitoring Program (RAMP) played pivotal roles in assessing community health, establishing baseline data, and tracking changes in the Lower Athabasca sub-watershed. Spatial variability in benthic communities was evident, attributed to factors such as substrate stability and sediment texture. Long-term monitoring captured trends and assessed anthropogenic impacts. Biomonitoring approaches, exemplified by the CABIN protocol, standardized data collection. Ultimately, the studies underscore the health of the Lower Athabasca River, where conditions generally remain robust despite localized stress, as evidenced by abundant EPT taxa and a "Good" benthic health rating as of 2020.

Several notable data gaps have emerged while exploring the various sub-watersheds within the Athabasca watershed. For instance, the Pembina River and La Biche sub-basins need more recent studies and sampling efforts on benthic invertebrates, highlighting an area that warrants attention for future research. Similar data gaps exist in the Lake Athabasca sub-watershed, underscoring the need for extensive sampling efforts to learn more about the benthic invertebrate communities in this area.

Given that there is a lot of agricultural activity in the Pembina and La Biche sub-watersheds and the central region of the Athabasca watershed, it is interesting to think about the potential effects of riparian habitat on benthic invertebrate communities. This raises an important research question about the relationship between benthic invertebrate population health and composition and land use practices like agriculture.

Conclusion

This report has summarized the current “what is known” about benthic invertebrates in the Athabasca watershed. Benthic invertebrate communities are influenced by their surrounding habitat and water quality. Therefore, it is important to know where, when, and how benthic invertebrates were collected in the Athabasca watershed.

References

Athabasca Watershed Council. (2013). State of the Watershed Report Phase 3: Water Quantity and Basic Water Quality in the Athabasca Watershed. Retrieved from http://athabascawater.wpengine.com/wp-content/uploads/2017/09/SOW3complete_compressed.pdf

Athabasca Watershed Council. (2021). Preliminary DNA Data: Upper Athabasca, AB. Retrieved from https://awc-wpac.ca/projects/upper-athabasca-biomonitoring/

Barton, D. R., & Wallace, R. R. (1979). Effects of eroding oil sand and periodic flooding on benthic invertebrate communities in a brown-water stream in northeastern Alberta, Canada. Canadian Journal of Zoology, 57, 533-541.

Barton, D. R. (1980a). Benthic macroinvertebrate communities of the Athabasca River near Ft. Mackay, Alberta. Hydrobiologia, 74, 151-160.

Barton, D. R. (1980b). Observations on the life histories and biology of Ephemeroptera and Plecoptera in Northeastern Alberta. Aquatic Insects, 2, 97-111.

Government of Canada. (2024). Canadian Aquatic Biomonitoring Network. (2024). Retrieved from https://www.canada.ca/en/environment-climate-change/services/canadian-aquatic-biomonitoring-network.html

Coal Valley Resources Inc. (2012). Robb Trend Project Environmental Impact Assessment and Mine Permit Application. Submitted April 2012.

Culp, J. M., Podemski, C. L., & Cash, K. J. (2000). Interactive effects of nutrients and contaminants from pulp mill effluents on riverine benthos. Journal of Aquatic Ecosystem Stress and Recovery, 8, 67-75.

Culp, J. M., Glozier, N. E., Baird, D. J., Wrona, F. J., Brua, R. B., Ritcey, A. L., ... & Suzanne, C. (2018). Assessing ecosystem health in benthic macroinvertebrate assemblages of the Athabasca River main stem, tributaries, and Peace-Athabasca Delta. Government of Alberta.

Culp, J. M., Brua, R. B., Luiker, E., & Glozier, N. E. (2020). Ecological causal assessment of the benthic condition in the oil sands region, Athabasca River, Canada. Science of the Total Environment, 749, 141393.

Golder Associates Ltd. (2003). Review of historical benthic invertebrate data for rivers and streams in the oil sands region. Retrieved from http://www.ramp-alberta.org/UserFiles/File/RAMPMonitoring/RAMP_Historical_Benthos_Report.pdf

Government of Alberta. (1996). Northern River Basins Study: Report to the Ministers. Retrieved from https://d3n8a8pro7vhmx.cloudfront.net/lswc/pages/1124/attachments/original/1619033546/northern_river_basins_study.pdf?1619033546

State of the Park Report: 2018 - Jasper National Park. (2018). Government of Canada. Retrieved from https://parks.canada.ca/pn-np/ab/jasper/gestion-management/plan/involved/sop

Regional Aquatic Monitoring Program. (2016). Final 2015 Program Report. Retrieved from http://www.ramp-alberta.org/UserFiles/File/RAMPMonitoring/RAMP_Historical_Benthos_Report.pdf

MacDonald, S. (2016). Upper Athabasca Community Based Monitoring Report: Water Quality.

McCart, P., Tsui, P., Grant, W., & Green, R. (1977). Baseline studies of aquatic environments in the Athabasca River near Lease 17. Syncrude Canada Ltd., Edmonton, Alberta. Environmental Research Monograph 1977-2.

Mueller, Z. (2015). Upper Athabasca Community Based Monitoring Report: Assessment of Heavy Metal Toxicity in Sediment and Water.

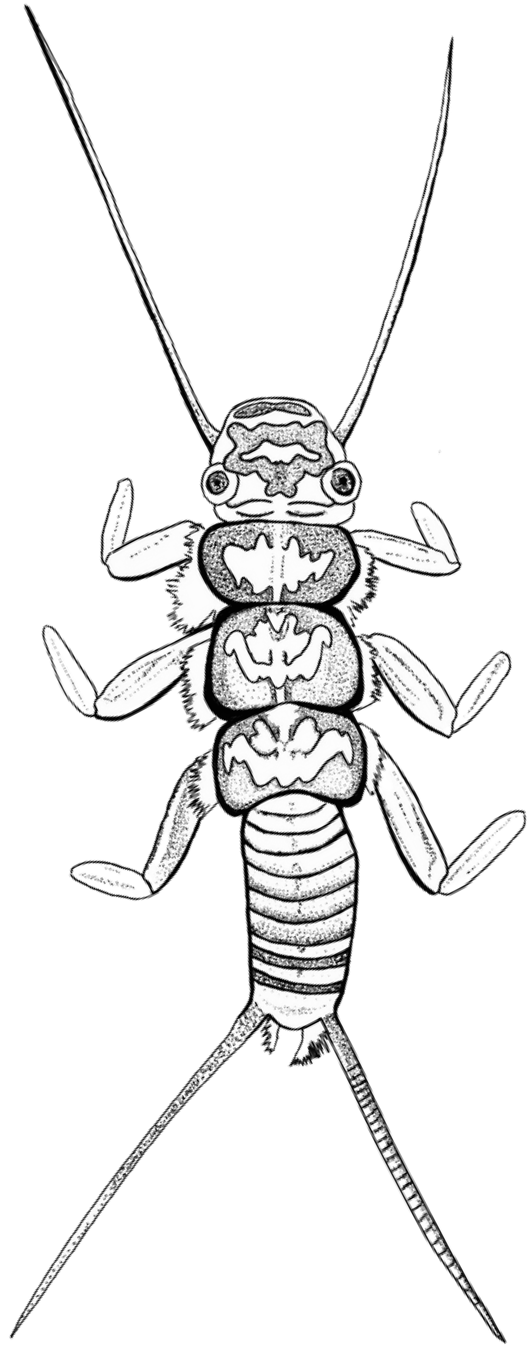
Pinsent, M. E. (1967). A comparative limnological study of Lac La Biche and Beaver Lake, Alberta. M. Sc. Thesis. Univ. Alberta, Edmonton, Alta.

R.L. & L. Environmental Services Ltd. (1993). Northern River Basins Study Project Report No. 5, Aquatic Macroinvertebrate Identifications, Upper Athabasca River, April and May, 1992, Edmonton, Alberta, Canada, June, 1993.

Reece, P. F., & Richardson, J. S. (1999). Biomonitoring with the reference condition approach for the detection of aquatic ecosystems at risk. In Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk (Vol. 2, pp. 549-552). BC Ministry of Environment.

Walder, G. L., & Mayhood, D. W. (1985). An analysis of benthic invertebrate and water quality monitoring data from the Athabasca River. Prepared for Alberta Environment, Research Management Division by Sigma Biometrics and FWR Freshwater Research Limited. RMD Report L-91. 254 pp.

World Wildlife Fund Canada. (2020). Peace-Athabasca Watershed Report. Retrieved from https://wwf.ca/wp-content/uploads/2020/10/PeaceAthabasca_TechDoc_2020_FINAL.pdf



“Common Stonefly” illustration by Ashley Johnson.

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